

What is claimed is:

1. A method for making a spark plug having a center electrode disposed inside an insulator, a metallic shell disposed outside the insulator, and a ground electrode having a base end side connected to a leading end surface of the metallic shell and a leading end side bent so as to have a side surface that is opposed to a leading end surface of the center electrode to form therebetween a spark gap, the method comprising the steps of:

for adjustment of a spark gap of a spark plug work having the center electrode and the ground electrode, provisionally pressing the ground electrode of the spark plug work toward the leading end surface of the center electrode and thereby decreasing the spark gap to a predetermined value larger than a final target gap  $g_t$ ;

after the step of provisionally pressing the ground electrode, performing an adjustment bending process for bending the ground electrode in the widthwise direction thereof so as to eliminate an eccentricity  $\delta$  of the ground electrode with respect to a target position;

after the step of performing the adjustment bending process, measuring a spark gap  $g_1$  of the spark plug work and measuring a difference  $(g_1 - g_t)$  between the measured spark gap  $g_1$  and the final target gap  $g_t$ ; and

pressing the ground electrode toward the center electrode when the difference  $(g_1 - g_t)$  is positive.

2. A method according to claim 1, wherein the step of performing the adjustment bending process comprises

performing the adjustment bending process for ground electrodes of a plurality of spark plug works to adjust positions of the ground electrodes in the width direction thereof by adjustment amounts  $\mu$ , measuring  
5 resulting displacement amounts  $\lambda$  of the ground electrodes in a pressed direction, finding the adjustment amount  $\mu$  from an adjustment amount function  $\mu = F(\lambda)$  that is a function of the displacement amount  $\lambda$ , and finding, based on the  
10 adjustment amount function  $\mu = F(\lambda)$ , the adjustment amount  $\mu$  necessary for eliminating the eccentricity  $\delta$  of the ground electrode with respect to the target position.

15 3. A method according to claim 2, wherein the step of performing the adjustment bending process comprises updating sets of  $(\mu, \lambda)$  data of the adjustment amount  $\mu$  and the displacement amount  $\lambda$  by  $(\mu, \lambda)$  data newly collected upon manufacture of the spark plug, and  
20 using while updating the adjustment amount function  $\mu = F(\lambda)$  based on the updated sets of  $(\mu, \lambda)$  data.

4. A method according to claim 3, wherein the step of performing the adjustment bending process comprises  
25 obtaining the adjustment amount function  $\mu = F(\lambda)$  based on the sets of  $(\mu, \lambda)$  data of all of the spark plug works preceding a present spark plug work.

5. A method according to claim 3, wherein the step  
30 of performing the adjustment bending process comprises obtaining the adjustment amount function  $\mu = F(\lambda)$  based on the sets of  $(\mu, \lambda)$  data of a predetermined number

of the spark plug works immediately before a present spark plug work.

6. A method according to claim 1, wherein the step  
5 of performing the adjustment bending process comprises obtaining the adjustment amount function  $\mu = F(\lambda)$  as a linear function of  $\lambda$  by least square regression of the sets of  $(\mu, \lambda)$  data of the adjustment amount  $\mu$  and the displacement amount  $\lambda$ .

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7. A method according to claim 6, further comprising the steps of:

prior to beginning of manufacture of the spark plug, obtaining an initial approximation function  $\mu$   
15  $= F'(\lambda)$  as a function of n-th degree by using the sets of  $(\mu, \lambda)$  data having been obtained beforehand with respect to a predetermined n-number of spark plug works, and for the spark plug works till the n-th after beginning of manufacture, finding the adjustment  
20 amount  $\mu$  from the initial approximation function  $\mu = F'(\lambda)$ ; and

for the spark plug works from n+1-th onward after beginning of manufacture, obtaining the adjustment amount function  $\mu = F(\lambda)$  as a linear  
25 function of  $\lambda$  by least square regression of the sets of  $(\mu, \lambda)$  data of all of the spark plug works prior to a present spark plug work and finding the adjustment amount  $\mu$  from the adjustment amount function  $\mu = F(\lambda)$ .

30 8. A method according to claim 7, wherein the step of obtaining the initial approximation function comprises preparing a required number of spark plug

works for experiment, making adjustments of a plurality of predetermined adjustment amounts  $\mu$  to the respective spark plug works to obtain resulting displacement amounts  $\lambda$ , and obtaining, by least square regression of thus obtained sets of  $(\mu, \lambda)$  data, the initial approximation function  $\mu = F'(\lambda)$  as a linear function of  $\lambda$ .

9. A method according to claim 8, wherein the step of obtaining the initial approximation function comprises obtaining, by the least square regression, a regression line  $\lambda = f(\mu)$  for regression of the displacement amounts  $\lambda$  to the adjustment amount  $\mu$ , and obtaining the initial approximation function  $\mu = F'(\lambda)$  as an inverse function of  $\lambda = f(\mu)$ .

10. A method according to claim 6, further comprising the steps of:

prior to beginning of manufacture of the spark plug, obtaining an initial approximation function  $\mu = F'(\lambda)$  as a function of n-th degree by using the sets of  $(\mu, \lambda)$  data having been obtained beforehand with respect to a predetermined n-number of spark plug works, and for the spark plug works till the n-th after beginning of manufacture, finding the adjustment amount  $\mu$  from the initial approximation function  $\mu = F'(\lambda)$ ; and

for the spark plug works from n+1-th onward after beginning of manufacture, obtaining the adjustment amount function  $\mu = F(\lambda)$  as a linear function of  $\lambda$  by least square regression of the sets

of  $(\mu, \lambda)$  data of all of the spark plug works prior to a present spark plug work and finding the adjustment amount  $\mu$  from the adjustment amount function  $\mu = F(\lambda)$ .

5 11. A method according to claim 10, wherein the step of obtaining the initial approximation function comprises preparing a required number of spark plug works for experiment, making adjustments of a plurality of predetermined adjustment amounts  $\mu$  to  
10 the respective spark plug works to obtain resulting displacement amounts  $\lambda$ , and obtaining, by least square regression of thus obtained sets of  $(\mu, \lambda)$  data, the initial approximation function  $\mu = F'(\lambda)$  as a linear function of  $\lambda$ .

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12. A method according to claim 11, wherein the step of obtaining the initial approximation function comprises obtaining, by the least square regression, a  
regression line  $\lambda = f(\mu)$  for regression of the  
20 displacement amount  $\lambda$  to the adjustment amount  $\mu$ , and obtaining the initial approximation function  $\mu = F'(\lambda)$  as an inverse function of  $\lambda = f(\mu)$ .

13. A method according to claim 1, wherein the step  
25 of measuring the spark gap and the step of pressing the ground electrode are repeated until the spark gap is adjusted to the final target gap  $gt$ .

14. A method according to claim 1, wherein the step  
30 of performing the adjustment bending process is

repeated until the eccentricity  $\delta$  is adjusted to a final target deviation  $\delta t$ .

15. A method of making a spark plug having a center  
5 electrode and a ground electrode having a base end side joined to an end surface of a metallic shell and a leading end side opposed to the center electrode so as to form a spark gap therebetween, the method comprising:

10 performing an adjustment bending process of a plurality of spark plug works having the center electrodes and the ground electrodes for making adjustments of positions of the ground electrodes in the width direction thereof by an adjustment amount  $\mu$ ;

15 measuring resulting displacement amounts  $\lambda$  of the ground electrodes in the width direction thereof and finding the adjustment amount  $\mu$  from  $\mu = F(\lambda)$  that is a function of the displacement amount  $\lambda$ ; and

finding an adjustment amount necessary for  
20 eliminating the eccentricity  $\delta$  of the ground electrode with respect to a target position based on the adjustment amount function  $\mu = F(\lambda)$ .

16. An apparatus for making a spark plug having a  
25 center electrode disposed inside an insulator, a metallic shell disposed outside the insulator, and a ground electrode having a base end side connected to a leading end surface of the metallic shell and a leading end side bent so as to have a side surface  
30 that is opposed to a leading end surface of the center electrode to form therebetween a spark gap, the apparatus comprising:

a pair of first and second pressing devices for adjustment of a spark gap of a spark plug work having the center electrode and the ground electrode;

a bending device for adjustment of an  
5 eccentricity of the ground electrode of the spark plug work; and

a controller for controlling the first and second pressing devices and the bending device;

the controller being programmed to:

10 actuate, for adjustment of the spark gap of the spark plug work, the first pressing device to provisionally press the ground electrode of the spark plug work toward the leading end surface of the center electrode and thereby decrease the spark gap to a  
15 predetermined value larger than a final target gap  $g_t$ ;

actuate, after the provisional pressing of the ground electrode, the bending device to perform an adjustment bending process for bending the ground electrode in the widthwise direction thereof so as to  
20 eliminate an eccentricity  $\delta$  of the ground electrode with respect to a target position;

measure, after the adjustment bending process, a spark gap  $g_1$  of the spark plug work and measure a difference ( $g_1 - g_t$ ) between the measured spark gap  $g_1$   
25 and the final target gap  $g_t$ ; and

actuate the second pressing device to press the ground electrode toward the center electrode when the difference ( $g_1 - g_t$ ) is positive.

30 17. An apparatus according to claim 16, wherein the controller is further programmed to perform the adjustment bending process for ground electrodes of a plurality of spark plug works to adjust positions of

the ground electrodes in the width direction thereof by adjustment amounts  $\mu$ , measure resulting displacement amounts  $\lambda$  of the ground electrodes in a pressed direction, find the adjustment amount  $\mu$  from  
5 an adjustment amount function  $\mu = F(\lambda)$  that is a function of the displacement amount  $\lambda$ , and find, based on the adjustment amount function  $\mu = F(\lambda)$ , the adjustment amount  $\mu$  necessary for eliminating the eccentricity  $\delta$  of the ground electrode with respect to  
10 the target position.

18. An apparatus according to claim 17, wherein the controller is further programmed to update sets of ( $\mu$ ,  $\lambda$ ) data of the adjustment amount  $\mu$  and the  
15 displacement amount  $\lambda$  by data ( $\mu$ ,  $\lambda$ ) newly collected upon manufacture of the spark plug, and use while updating the adjustment amount function  $\mu = F(\lambda)$  based on the sets of updated ( $\mu$ ,  $\lambda$ ) data.

20 19. An apparatus according to claim 18, wherein the controller is further programmed to obtain the adjustment amount function  $\mu = F(\lambda)$  based on the sets of ( $\mu$ ,  $\lambda$ ) data of all of the spark plug works preceding a present spark plug work or the sets of ( $\mu$ ,  
25  $\lambda$ ) data of a predetermined number of the spark plug works immediately before a present spark plug work.

20. An apparatus according to claim 16, wherein the controller is further programmed to obtain the  
30 adjustment amount function  $\mu = F(\lambda)$  as a linear function of  $\lambda$  by least square regression of the sets

of,  $(\mu, \lambda)$  data of the adjustment amount  $\mu$  and the displacement amount  $\lambda$ .

21. An apparatus according to claim 20, wherein the  
5 controller is further programmed to:

prior to beginning of manufacture of the spark plug, obtaining an initial approximation function  $\mu = F'(\lambda)$  as a function of n-th degree by using the sets of  $(\mu, \lambda)$  data having been obtained beforehand  
10 with respect to a predetermined n-number of spark plug works, and for the spark plug works till the n-th after beginning of manufacture, finding the adjustment amount  $\mu$  from the initial approximation function  $\mu = F'(\lambda)$ ; and

15 for the spark plug works from n+1-th onward after beginning of manufacture, obtaining the adjustment amount function  $\mu = F(\lambda)$  as a linear function of  $\lambda$  by least square regression of the sets of  $(\mu, \lambda)$  data of all of the spark plug works prior to  
20 a present spark plug work and finding the adjustment amount  $\mu$  from the adjustment amount function  $\mu = F(\lambda)$ .

22. An apparatus according to claim 21, wherein the  
25 controller is further programmed to prepare a required number of spark plug works for experiment, making adjustments of a plurality of predetermined adjustment amounts  $\mu$  to the respective spark plug works to obtain resulting displacement amounts  $\lambda$ , and obtain, by least square regression of thus obtained sets of  
30  $(\mu, \lambda)$  data, the initial approximation function  $\mu = F'(\lambda)$  as a linear function of  $\lambda$ .

23. An apparatus according to claim 22, wherein the controller is further programmed to obtain, by the least square regression, a regression line  $\lambda = f(\mu)$  for regression of the displacement amount  $\lambda$  to the  
5 adjustment amount  $\mu$ , and obtain the initial approximation function  $\mu = F'(\lambda)$  as an inverse function of  $\lambda = f(\mu)$ .

24. An apparatus according to claim 20, wherein the  
10 controller is further programmed to:

prior to beginning of manufacture of the spark plug, obtaining an initial approximation function  $\mu = F'(\lambda)$  as a function of n-th degree by using the sets of  $(\mu, \lambda)$  data having been obtained beforehand  
15 with respect to a predetermined n-number of spark plug works, and for the spark plug works till the n-th after beginning of manufacture, finding the adjustment amount  $\mu$  from the initial approximation function  $\mu = F'(\lambda)$ ; and

20 for the spark plug works from n+1-th onward after beginning of manufacture, obtaining the adjustment amount function  $\mu = F(\lambda)$  as a linear function of  $\lambda$  by least square regression of the sets of  $(\mu, \lambda)$  data of all of the spark plug works prior to  
25 a present spark plug work and finding the adjustment amount  $\mu$  from the adjustment amount function  $\mu = F(\lambda)$ .

25. An apparatus according to claim 24, wherein the controller is further programmed to prepare a required  
30 number of spark plug works for experiment, making adjustments of a plurality of predetermined adjustment

amounts  $\mu$  to the respective spark plug works to obtain resulting displacement amounts  $\lambda$ , and obtain, by least square regression of thus obtained sets of ( $\mu$ ,  $\lambda$ ) data, the initial approximation function  $\mu = F'(\lambda)$  as a linear function of  $\lambda$ .

26. An apparatus according to claim 25, wherein the controller is further programmed to obtain, by the least square regression, a regression line  $\lambda = f(\mu)$  for regression of the displacement amount  $\lambda$  to the adjustment amount  $\mu$ , and obtain the initial approximation function  $\mu = F'(\lambda)$  as an inverse function of  $\lambda = f(\mu)$ .

27. An apparatus according to claims 16, wherein the controller is further programmed to measure the spark gap of the spark plug work and press the ground electrode repeatedly until the spark gap is adjusted to the final target gap  $gt$ .

28. An apparatus according to claims 16, wherein the controller is further programmed to perform the adjustment bending process repeatedly until the eccentricity  $\delta$  is adjusted to a final target deviation  $\delta t$ .

29. An apparatus for making a spark plug having a center electrode and a ground electrode having a base end side joined to an end surface of a metallic shell and a leading end side opposed to the center electrode so as to form a spark gap therebetween, the apparatus comprising:

means for performing an adjustment bending process of a plurality of spark plug works having the center electrodes and the ground electrodes for making adjustments of positions of the ground electrodes in the width direction thereof by adjustment amount  $\mu$ ;

means for measuring resulting displacement amounts  $\lambda$  of the ground electrodes in the width direction thereof and finding the adjustment amount  $\mu$  from  $\mu = F(\lambda)$  that is a function of the displacement amount  $\lambda$ ; and

means for finding an adjustment amount necessary for eliminating the eccentricity  $\delta$  of the ground electrode with respect to a target position based on the adjustment amount function  $\mu = F(\lambda)$ .

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